



# Overall CERN view, status and plans

10<sup>th</sup> Edition of the Large Hadron Collider Physics Conference

Joachim Mnich

May 16<sup>th</sup>, 2022

# Outline

- Start of Run 3
- COVID
- Impact of Russian War on Ukraine
- LHC future plans
- Status FCC feasibility study
- Non-LHC and Physics Beyond Colliders

# Preparation for Run 3

- Phase I upgrades of the 4 large LHC experiments successfully completed and ready for data taking

A truly remarkable success in view of the very difficult circumstances during the pandemic!

- A few examples:

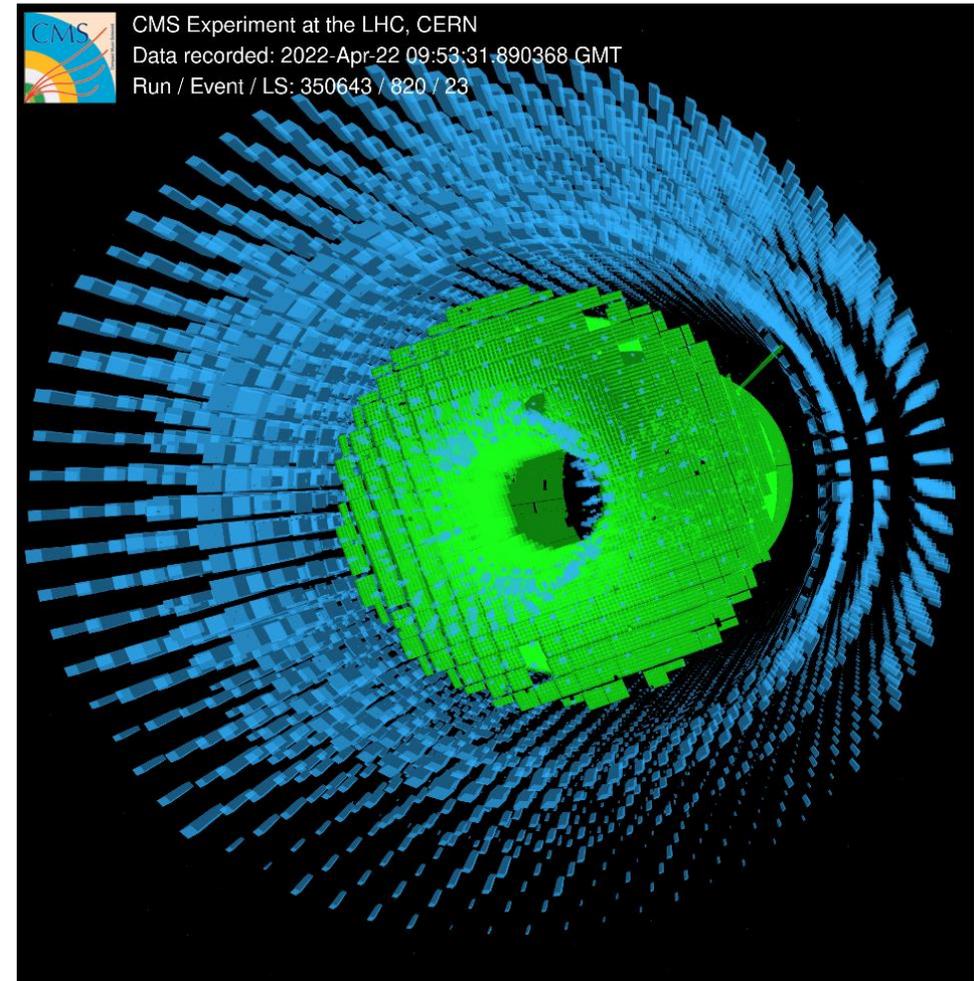
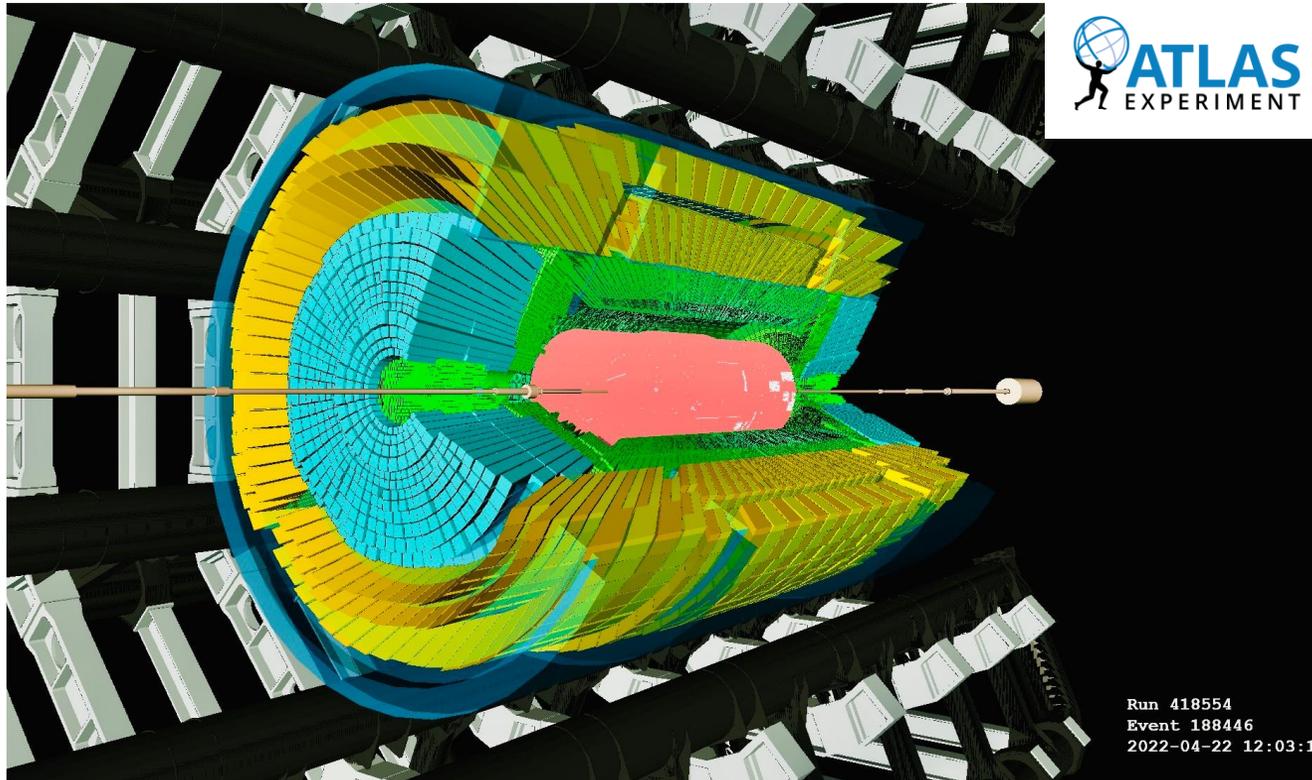


## LHCb Scintillating Fibre Tracker



# LHC Restart

- April 22<sup>nd</sup>, 2022:  
First circulating proton beams in the LHC
- “Splash” events recorded by the four detectors



- First collisions at 13.6 TeV cms energy expected in a few weeks

# FASER & SND@LHC

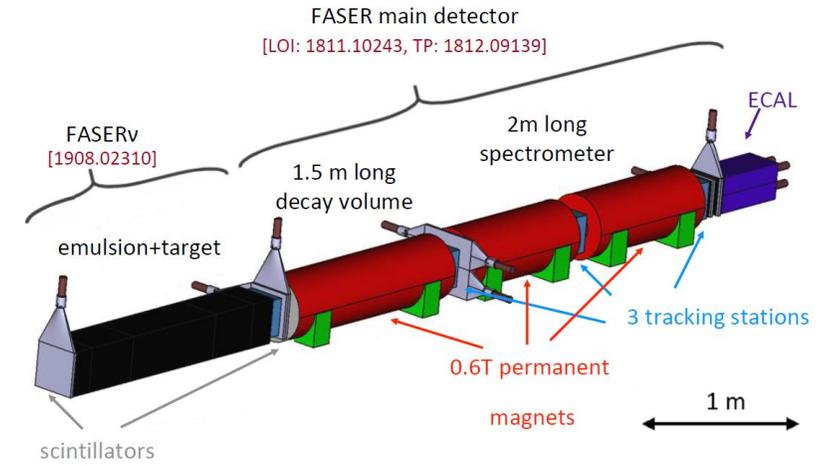
2 new experiments installed on both sides of ATLAS

FASER:

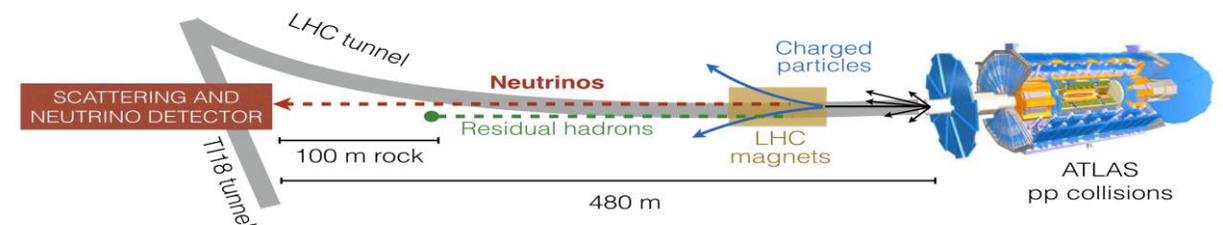
- designed to search for light and extremely weakly interacting particles
- on the collision axis
- FASERv is a subdetector of FASER, designed to detect neutrinos

SND@LHC

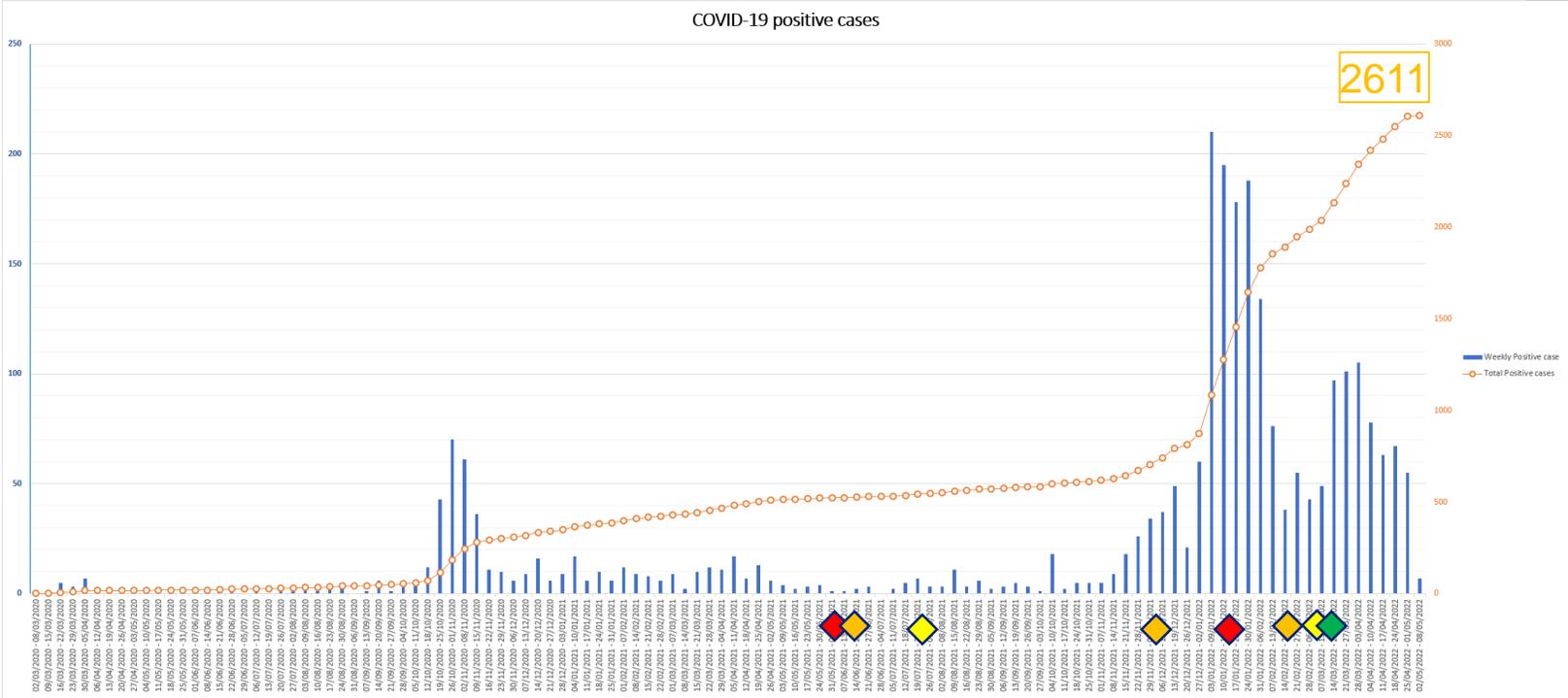
- collider neutrinos, unexplored energy domain bridging to atmospheric neutrinos from high-energy cosmic rays
- slightly off-axis provides better sensitivity to neutrinos produced in charm decay
- probe gluon PDFs in unexplored  $x$  ( $10^{-6}$ ) range
- search for feebly interacting particles



TI12 tunnel after FASER installation



# Covid Cases at CERN (Personnel + Contractors)



↑  
Xmas  
break

↑  
14.03.2022 Green level  
(with some additional measures)

COVID-19 <https://hse.cern>  
Coronavirus information

## CERN'S COVID-19 SCALE AND MEASURES

The COVID-19 level in place reflects the prevailing epidemiological situation, and determines corresponding measures across the Laboratory.

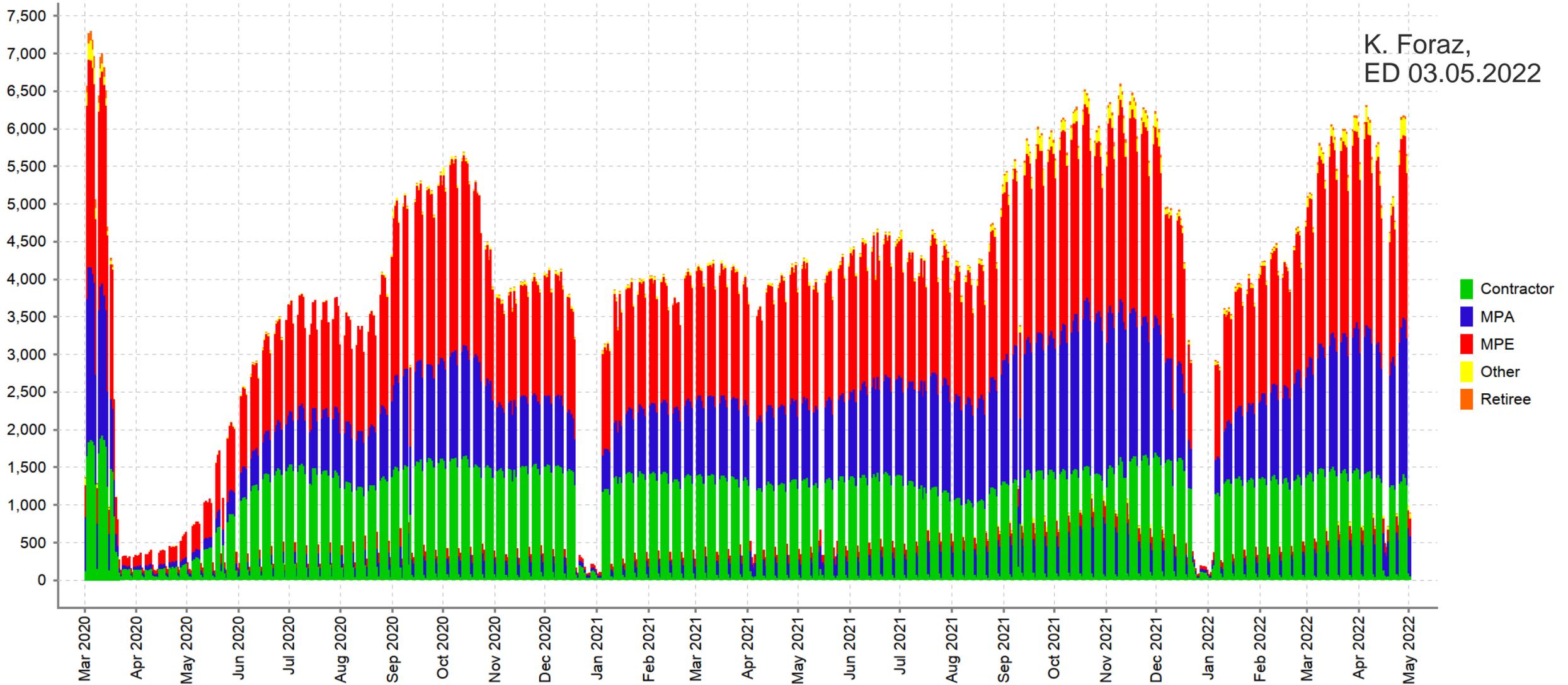
**TRANSITION BETWEEN LEVELS**  
Determined via a combination of the incidence rate in the local area and a qualitative assessment by CERN.



| Level                                  | 4  | 3   | 2   | 1                               |
|--|--|---|---|---------------------------------|
| Weekly virus circulation in local area | High<br>Over 100 cases per 100 000   | Medium<br>Over 10-25 cases per 100 000  | Low<br>Fewer than 10-25 cases per 100 000   | Negligible                      |
| Qualitative assessment                 | Based on number of confirmed cases at CERN, presence of new variants, vaccination, stratified testing campaign, etc. |   |   |                                 |
| Telework (TW) measures*                | Members of personnel (MP) who can telework should telework, though one day per week on-site is possible.             | MP who can telework should telework, though two days per week on-site are possible. | Normal working conditions apply. Telework may be exceptionally requested by the Organization. | Normal working conditions apply |
| Access to CERN sites**                 | MP and honorary members are authorised, only for professional reasons and in consultation with their                 | MP and honorary members are authorised in   | MP and honorary members are authorised in   | Standard Access                 |

Number of individuals seen at CERN sites per date by CLASS group as of 02 May 2022

K. Foraz,  
ED 03.05.2022



# Russian War on Ukraine

The Russian military aggression against Ukraine contradicts CERN values and CERN condemns this war in the strongest possible terms!

## Measures taken by CERN Council:

Statement from 25 March:

<https://home.cern/news/news/cern/cern-council-takes-further-measures-response-invasion-ukraine>

In response to the military invasion of Ukraine by the Russian Federation, the 23 Member States of CERN today decided to:

- suspend the participation of CERN scientists in all scientific committees of institutions located in the Russian Federation and the Republic of Belarus, and vice versa;
- suspend or, failing that, cancel all events jointly arranged between CERN and institutions located in the Russian Federation and the Republic of Belarus;
- suspend the granting of contracts of association as associated members of the CERN personnel to any new individuals affiliated to home institutions in Russia and Belarus.

# Measures taken by CERN Council

Regarding relations with the Joint Institute for Nuclear Research (JINR), with which CERN holds reciprocal Observer status, the CERN Council decided:

- to suspend the participation of CERN scientists in all JINR scientific committees, and vice versa;
- to suspend or, failing that, cancel all events jointly arranged between CERN and JINR;
- that CERN will not engage in new collaborations with JINR until further notice;
- that the Observer status of JINR at the Council is suspended and CERN will not exercise the rights resulting from its Observer status at JINR, until further notice.

Council have asked for more information with a view to making a decision in June on the possible suspension of international cooperation agreements

# Risks Associated with the War Against Ukraine

Russian, Belarussian and Ukrainian institutes are strong and important partners in the CERN programme

- Close to 7% of the members of the LHC collaborations are from institutes in Russia (incl. JINR)
- They are essential for the operation of the experiments  
Most critical examples:
  - ALICE: Fast Interaction Trigger, Photon Spectrometer, ...
  - ATLAS: Inner Detector, Tile Calo, TDAQ, Technical Coordination, ...
  - CMS: HCAL, CSC, BRIL, Technical Coordination, ...
  - LHCb: Muon systems, ECAL, HCAL, ..
- More than 100 scientists, engineers and technicians are crucial for the operation of the four detectors

Recall the **HUGE** contributions Russian, JINR (also Belarussian, Ukrainian) technicians, engineers and physicists made to the construction and operation of the detectors

Members from Russian institutes in the LHC collaborations

|       | Total | Russia (incl. JINR) |      | JINR |      |
|-------|-------|---------------------|------|------|------|
| ALICE | 1942  | 167                 | 8.5% | 34   | 1.7% |
| ATLAS | 5917  | 364                 | 6.2% | 147  | 2.5% |
| CMS   | 5365  | 306                 | 5.4% | 88   | 1.6% |
| LHCb  | 1500  | 148                 | 9.9% | 0    | 0%   |
| Sum   | 14724 | 985                 | 6.7% | 269  | 1.8% |

Collaborators essential for the operation of the LHC experiments

|       | Russia (incl. JINR) | JINR |
|-------|---------------------|------|
| ALICE | 20                  | 5    |
| ATLAS | 44                  | 15   |
| CMS   | 34                  | 10   |
| LHCb  | 15                  | 0    |
| Sum   | 113                 | 30   |

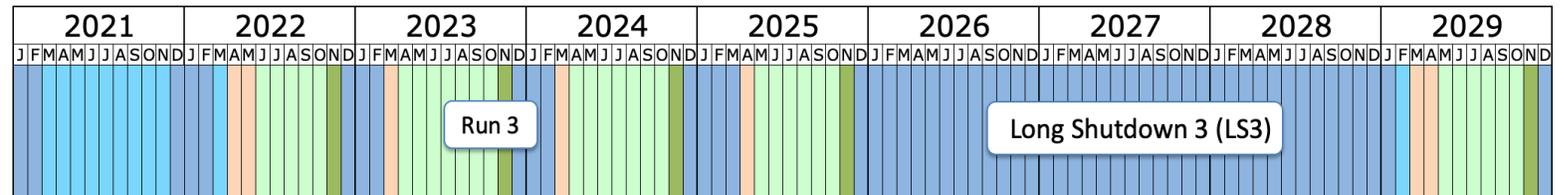
# LHC Schedule

Recall schedule discussion of December 2021:

- following recommendations of LHCC and HL-LHC Cost & Schedule Review CERN management proposed to extend Run 3 by 1 year and LS3 by 1/2 year
- feedback from funding agencies (RRB) was supportive
- **CERN management decided in January 2022 to adapt the schedule as proposed**  
underlining that any further shift of LS3 is technically excluded!

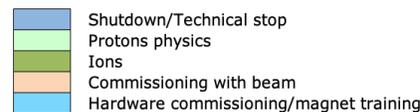
**Phase II upgrade  
ATLAS & CMS**

Both experiments and CERN are working hard to consolidate the schedule



**ALICE 3 & LHCb  
upgrade II**

Last updated: January 2022



# Long-term LHC Schedule

- The HL-LHC goal of providing  $3000 \text{ fb}^{-1}$  integrated luminosity to ATLAS and CMS would require HL-LHC operation until  $\approx 2041$
- Ending HL-LHC in 2038 would provide  $\approx 2500 \text{ fb}^{-1}$  per experiment

More details on long-term schedule are being worked on

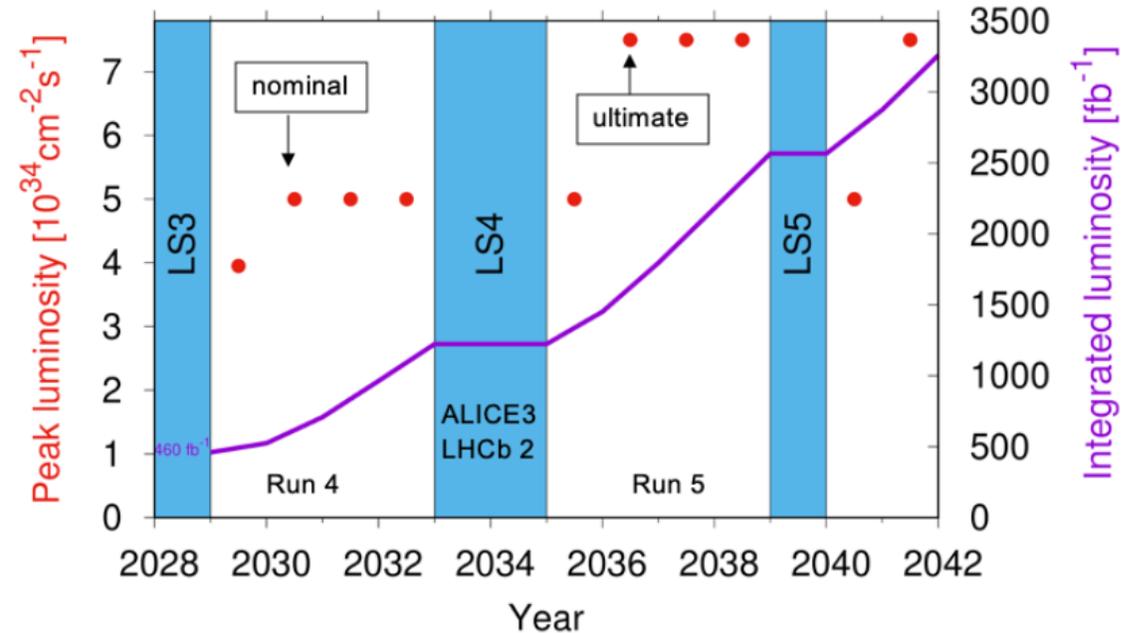
- Luminosity predictions
- **HI running is included in the current planning**
- Upgrades of ALICE and LHCb in LS 4
  - Currently under LHCC scrutiny
  - Discussions with Funding Agencies starting
- and others

Boundary condition:

**no HL-LHC running beyond  $\approx 2041$**

in light of the need for a future large project

Preliminary (optimistic) schedule of HL-LHC



Final decision on the long-term HL-LHC schedule will have to be taken at the next (or next-to-next?) strategy update in light of:

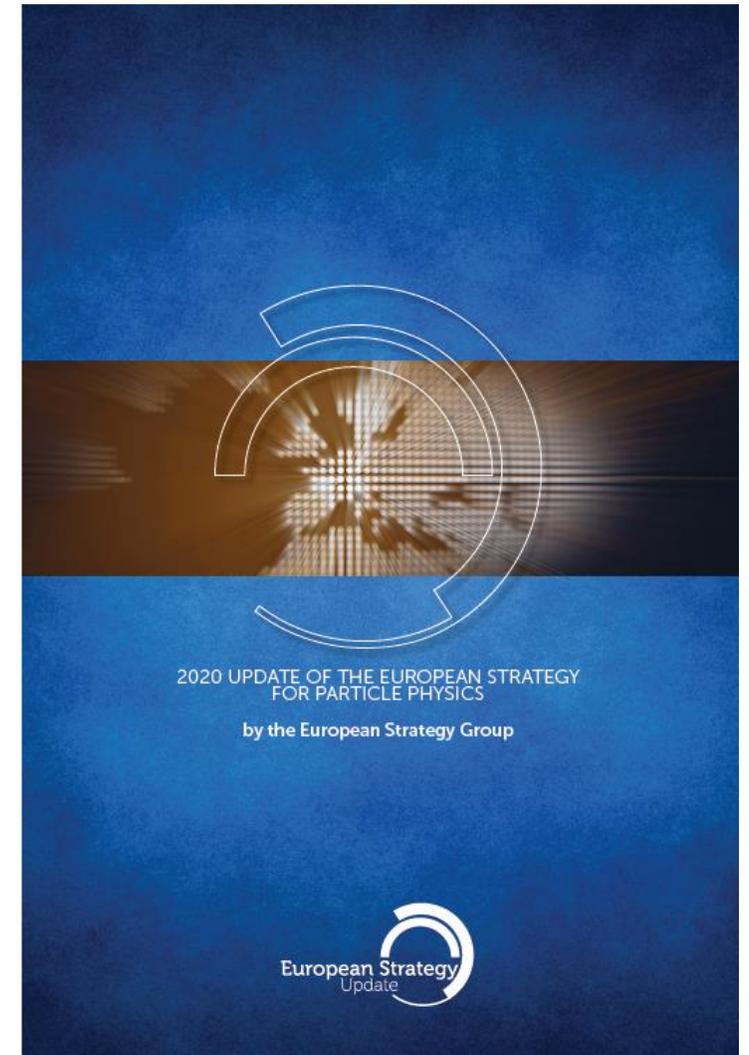
- performance and results from the LHC, progress with the next project (FCC), ...

# Future Circular Collider (FCC): Feasibility Study

European Strategy for Particle Physics:

- An *electron-positron Higgs factory* is the *highest-priority next collider*. For the longer term, the European particle physics community has the *ambition to operate a proton-proton collider at the highest achievable energy*.
- “Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage.
- Such a feasibility study of the colliders and related infrastructure should be established as a *global endeavour* and be completed on the timescale of the *next Strategy update*.”

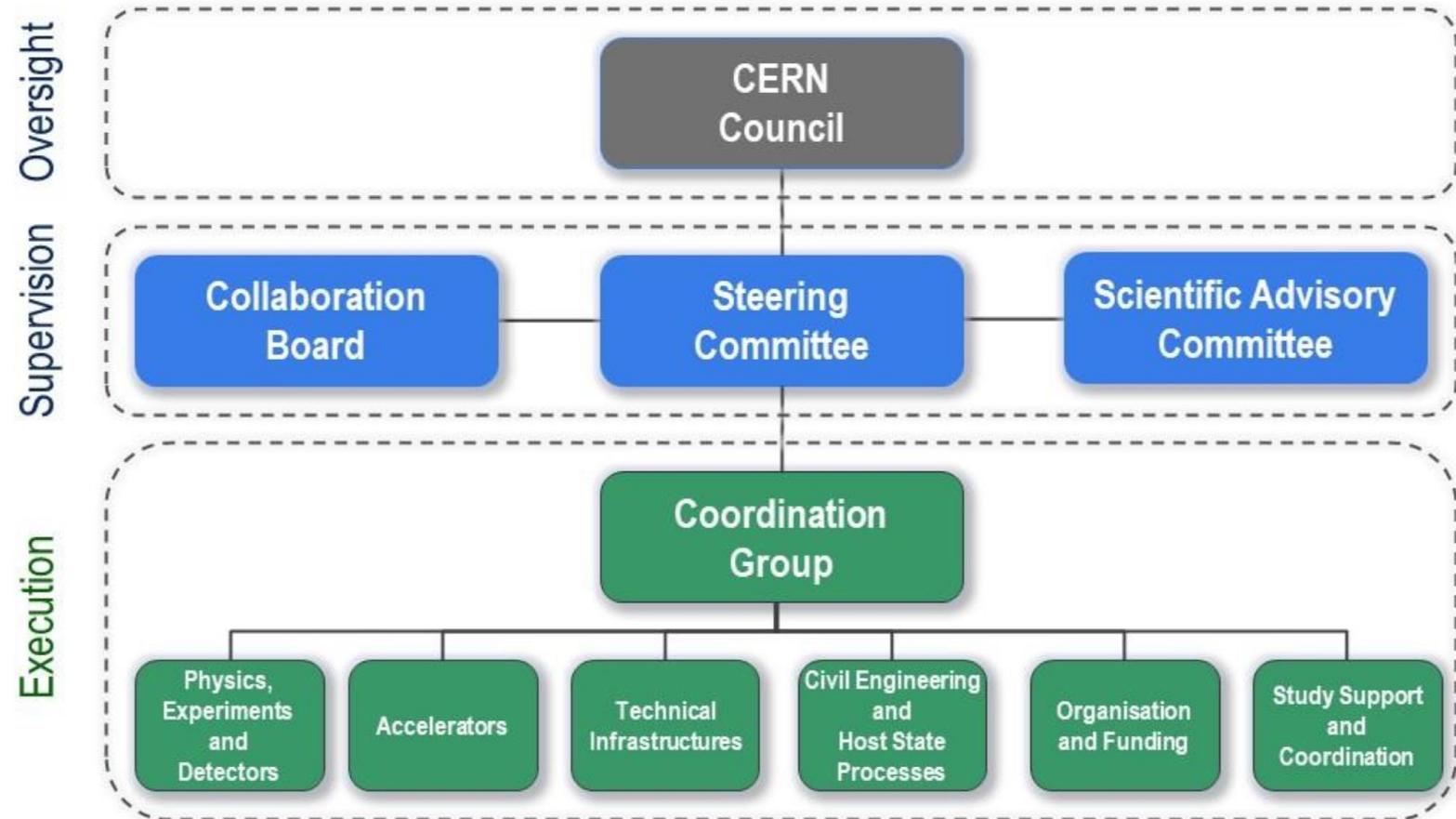
CERN has launched the FCC feasibility study to address these recommendations



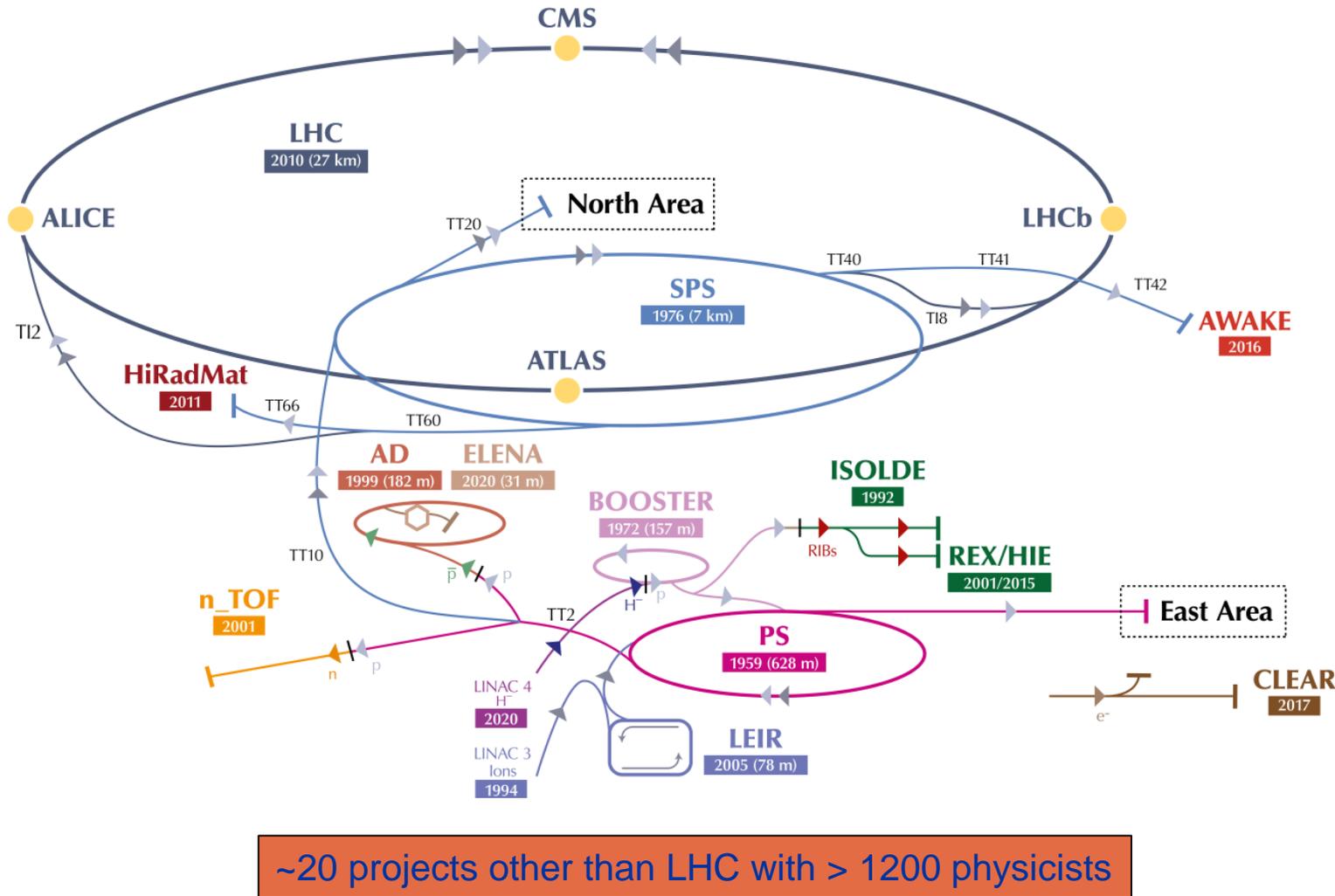
# Organisation of the Feasibility Study

Structure unanimously approved by CERN Council in June 2021

- Evolution of current structure
- Ownership by CERN Council
- Representatives of the worldwide FCC community
- Participation of external stakeholders envisaging to make significant financial contributions to possible future project



# CERN Diverse Physics Programme



- AD: Antiproton Decelerator for antimatter studies
- AWAKE: proton-induced plasma wakefield acceleration
- CAST, OSQAR: axions
- CLOUD: impact of cosmic rays on aerosols and clouds → implications on climate
- COMPASS: hadron structure and spectroscopy
- ISOLDE: radioactive nuclei facility
- LHC
- NA1/SHINE: ions and neutrino targets
- NA62: rare kaon decays
- NA63: radiation processes in strong EM fields
- NA64: search for dark photons
- Neutrino Platform:  $\nu$  detector R&D for experiments in US, Japan
- n-TOF: n-induced cross-sections
- UA9: crystal collimation

# Physics Beyond Colliders Study

Future of CERN's diverse science programme

PBC study launched in 2016 aimed at exploiting the full scientific potential of CERN's accelerator complex and its scientific infrastructure

<http://pbc.web.cern.ch/>

- complementary to LHC and other high-energy colliders
- target fundamental physics questions that are similar in spirit to those addressed by high-energy colliders

Provided input to the ESPP

- PBC Summary Report: arXiv:1902.00260

Study is continuing

Topics include:

- LHC injectors:
- Low energy facilities
- High energy fixed target
- Other opportunities gamma-factory
- nuSTORM @CERN
- Precision measurement and rare decays
- High energy beam dumps
- Low energy hidden sector (axions, EDM)
- QCD and HI

Study leaders:

Joerg Jaeckel (Heidelberg)

Mike Lamont (CERN) → Gianluigi Arduini

Claude Vallee (Marseille)



# 10<sup>th</sup> Anniversary of Higgs Boson Discovery



On 4 July 2022, CERN will mark 10 years since the ATLAS and CMS experiments announced the discovery of the Higgs boson.

The centrepiece is a full-day scientific symposium in CERN's main auditorium. This will celebrate the discovery, give an overview of what's been learned since then, and take a look forward at what's still to come.

Full details will be published soon but, in the meantime, save the date of 4 July 2022!

# CERN Family

## 23 Member States:

Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Serbia, Spain, Sweden, Switzerland, United Kingdom

## 10 Associate Member States:

Croatia, Cyprus\*, Estonia\*, India, Latvia, Lithuania, Pakistan, Slovenia\*, Turkey, Ukraine

\* in the pre-stage to Membership

## 4 Observers:

Japan, USA, European Union, UNESCO  
(Russia and JINR suspended on 8 and 25 March, respectively)

## ~60 ICA (International Cooperation Agreements):

with non-Member States, some with countries with developing particle physics communities (CERN mission is also to help build capacity and foster growth of particle physics worldwide).



March 3, 2022: CERN Director-General Fabiola Gianotti and Brazilian Minister for Science, Technology and Innovation Marcos Pontes signed an agreement admitting Brazil as an Associate Member State of CERN

Agreement awaiting ratification by the Government

**Thank you for your attention!**



# Backup

# Guidance on publications

Following the Russian invasion of Ukraine, the spokespersons of the four big LHC experiments proposed a suspension of publications.

CERN management will not interfere with the publication choices of the Collaborations, but supported this approach as being pragmatic given the current circumstances.

CERN management can now pass on guidance from the closed Council session regarding publications:

*“Authorship should be based on scientific grounds, and that Council would be favourable of having a cover statement that a given paper is based on work performed before Feb 24th 2022”*

The Collaboration Boards of the four large LHC experiments considered proposals based on this guidance, and aiming to align their policies.

# Agreement among the 4 LHC Collaborations

Until the guidance or rule changes issued from the 16/17 June CERN Council have been implemented:

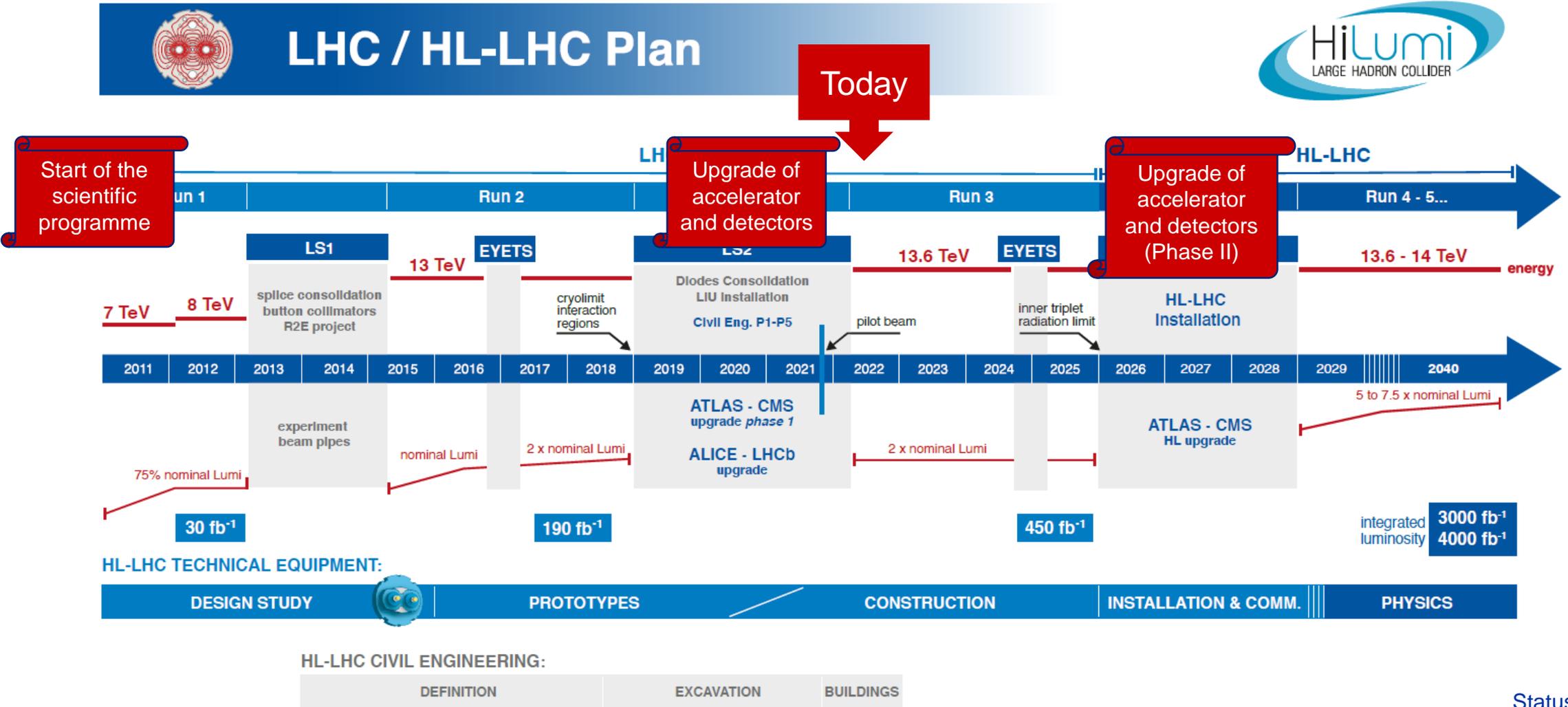
- Submit papers to arXiv.org and to CDS with “The XYZ Collaboration” only, that is, without author list nor acknowledgments.
- Submit the papers without author list and acknowledgments to journals for review. If a paper is accepted for publication before the June CERN Council meeting, a delay in publication will be requested.

The submitted papers would contain final results. Any release of preliminary results is continued in the usual manner.

# The LHC Scientific Programme



## LHC / HL-LHC Plan



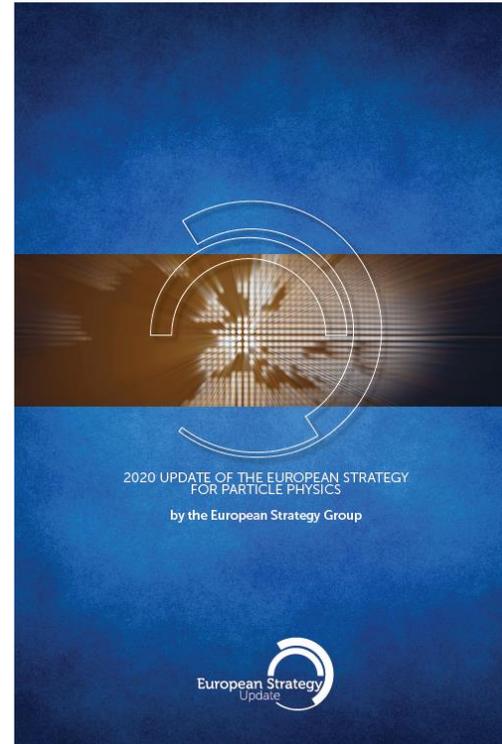
Status Feb 2022

# Reminder Update European Strategy for Particle Physics

CERN Council updated the European Strategy for Particle Physics in June 2020

## Scientific recommendations

- Full exploitation of the LHC and HL-LHC
- Highest-priority next collider: e+e- Higgs factory
- Increased R&D on accelerator technologies
- Investigation of the technical and financial feasibility of a future  $\geq 100$  TeV hadron collider
- Long-baseline neutrino projects in US and Japan
- High-impact scientific diversity programme complementary to high-energy colliders
- R&D on detector and computing
- Theory



**Importance of collaboration between CERN and national labs highlighted**

## Other high priority items:

- Exploit synergies with neighboring field, in particular nuclear and astroparticle physics
- Mitigate environmental impact of particle physics
- Invest in next generation of researchers
- Support knowledge and technology transfer
- Public engagement, education and communication

**ESPPU provides guidelines to CERN for the coming years**

# Feasibility study timeline

